Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal Form

Section 1. General administrative information

Life history and survival of fall chinook salmon in Columbia River basin

Bonneville project number, if an ongoing project 9102900

Business name of agency, institution or organization requesting funding
U.S. Geological Survey - Biological Resources Division

Business acronym (if appropriate) USGS

Proposal contact person or principal investigator:

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Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
U.S. Fish and Wildlife Service	Idaho FRO P.O. Box 18	Ahsahka, ID 83520	William Connor
U.S. Fish and Wildlife Service	Dworshak Fish Health Center P.O Box 18	Ahsahka, ID 83520	Kathy Clemens
Idaho Cooperative Fish and Wildlife Unit	University of Idaho	Moscow, ID 83843	Dr. Ted Bjornn

NPPC Program Measure Number(s) which this project addresses.
7.5B.3 , 7.3B.5

NMFS Biological Opinion Number(s) which this project addresses.

NMFS BO RPA 13f: “The BPA shall evaluate juvenile survival during downstream migration and desired level of flow augmentation.”

NMFS Consultation No. 0682: “NPT hatchery operations 1998-2002.”

Other planning document references.

If the project type is “Watershed” (see Section 2), reference any demonstrable support from affected agencies, tribes, local watershed groups, and public and/or private landowners, and cite available documentation.

Wy Kan Ush Me Wa Kush Wi Artificial Production Actions for the Snake River Mainstem Action 8: Monitor and evaluate all artificial production actions. Use adaptive management to determine whether program changes (i.e., release number, size, time, location, and/or life history) are needed in order to meet restoration objectives.

Snake River Salmon Recovery Plan measure 4.1.d. “By April 1, 1996, the fisheries agencies, Tribes, and IPC should work with NMFS, in consultation with the Fish Production Committee, to develop and implement management plans for Snake River fall chinook salmon gene bank and supplementation programs. These plans should include: #5 Reintroduction and supplementation strategy”

Subbasin.

Snake River, Columbia River

Short description.

Facilitate implementation of tribal and federal fall chinook salmon recovery plans by monitoring and evaluating post-release attributes and survival of naturally produced fall chinook salmon smolts, and Lyons Ferry Hatchery yearling and subyearling fall chinook salmon juveniles, released primarily in the Snake River.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production		Population dynamics
	Oceans/estuaries	X	Research		Ecosystems
	Climate	+	Monitoring/eval.	+	Flow/survival
	Other		Resource mgmt		Fish disease
			Planning/admin.	X	Supplementation
			Enforcement		Wildlife habitat en-hancement/restoration
			Acquisitions		

Other keywords.

natural life history timing, survival, hatchery-wild interactions, summer flow augmentation, habitat carrying capacity, temperature, predation, bioenergetics, migratory behavior

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
9302900	Survival estimates for the passage of juvenile salmonids through Snake River dams	Collaborative effort to estimate survival of hatchery and natural fall chinook in the Snake River
9403400	Assessing summer/fall chinook restoration in the Snake River basin	Collaborative effort to estimate survival of hatchery and natural fall chinook in the Snake and Clearwater rivers
9801003	Monitor and evaluate spawning distribution of Snake River Fall chinook salmon	Provide marked study fish for radio tracking adults and marked study fish life histories.

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Determine the effects of early life history timing on natural fall chinook salmon survival to the tail race of Lower Granite Dam.	a	Capture and PIT tag natural fall chinook salmon rearing in different areas of the Hells Canyon Reach.
		b	Provide real-time estimates of run timing to the Technical Advisory Committee for in-season summer flow management.
		d	Test for differences between emergence timing, seaward migration timing, and growth of fish tagged in different rearing areas.
		e	Determine if survival of natural fall chinook release groups is related to rearing area, emergence timing, growth, flow, temperature, and travel time.
2	Investigate the occurrence of autumn subyearling and spring yearling emigration in Snake	a	Determine the prevalence of subyearling holdover scale data collected from adults PIT tag

	River fall chinook salmon populations.		detection data for juveniles.
		b	Correlate the prevalence of holdover with environmental and genetic data.
		c	Determine the feasibility of estimating the origin of holdover fish using genetic and scale pattern data.
		d	Assess the likelihood of a natural fall chinook salmon population adopting a yearling emigration strategy if they were stocked in streams upstream of subyearling production areas.
3	Evaluate post-release attributes and survival of four fork lengths of Lyons Ferry Hatchery fall chinook salmon including yearlings (mean fork length = 160 mm) and subyearlings (mean fork lengths = 75 mm, 85 mm, and 95 mm).	a	Obtain and release sufficient numbers of hatchery fall chinook salmon to determine the effects of fork length and time of release on survival through lower Snake River dams.
		b	Estimate survival of each hatchery release group using a mark-recapture approach (Burnham et al. 1987)
		c	Use multivariate and analysis of variance statistics to test for similarities between hatchery release groups.
4	Define the effects of post-release attributes and the environmental conditions during rearing and emigration on survival estimates for each hatchery treatment and natural fall chinook salmon.	a	Define post-release dispersal patterns of hatchery fish in Hells Canyon.
		b	Describe post-release habitat use by hatchery fish to determine the extent of hatchery-wild overlap in nearshore rearing areas.
		c	Use radio telemetry to describe the migratory behavior of active

			migrants in the lower Snake River.
		d	Use multivariate and analysis of variance techniques to determine if differences in survival of hatchery groups are related to temperature, flow, and travel times.
5	Use a bioenergetics approach to assess potential growth advantage and predation risk for hatchery treatments and natural fall chinook salmon.	a	Develop a bioenergetics model to predict food consumption and growth of hatchery and wild fish in nearshore rearing areas.
		b	Determine the extent and size selectivity of predation by smallmouth bass on hatchery and wild subyearling fall chinook in the Hells Canyon Reach
		c	Use an individual-based bioenergetics model (Jager et al. 1993) to synthesize predation risk and growth advantage as it relates to survival, supplementation scenarios, and environmental conditions.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	08/1996	05/2001	20
2	08/1996	05/2001	20
3	08/1996	05/1999	20
4	08/1996	05/1999	20
5	08/1996	05/2001	20

Schedule constraints.

Flood conditions hampered the collection of juvenile fall chinook salmon in the Snake and Clearwater rivers in 1996 and 1997. Sample sizes were smaller than desired, but adequate for proposed analyses. Difficulties obtaining hatchery fish meeting our specified size and date requirements occurred in 1995 and in 1996, but not in 1997. The outlook is favorable for hatchery fish in 1998..

Completion date.

2001

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$270,000
Fringe benefits		$89,000
Supplies, materials, non-expendable property		$30,000
Operations & maintenance		
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		
PIT tags	# of tags: 10,000	$29,000
Travel		$15,000
Indirect costs	Administrative overhead	$152,000
Subcontracts	Cooperator: USFWS	$300,000
Other	Vehicle and boat operation	$15,000
TOTAL		$900,000

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$800,000	$700,000		
O&M as % of total	$0	$0		

Section 6. Abstract

The goal of this project is to help recover Snake River fall chinook salmon populations by providing real-time data and published, peer-reviewed information for adaptive management. There are five objectives including: 1) relating early life history timing of natural fall chinook salmon to smolt survival; 2) investigating residualism (i.e., holdover or yearling emigration) by natural fall chinook salmon; 3) evaluating post-release attributes and survival of out planted yearling and subyearling Lyons Ferry Hatchery fall chinook salmon; 4) defining the effects of post-release attributes and environmental conditions on natural and hatchery smolt survival; and 5) examining growth, predation, rearing habitat carrying capacity, and migratory behavior as mechanisms of survival as related to supplementation and flow augmentation. These objectives are consistent with measure number 7.3B.2 of the CBFWP. Objectives are being accomplished by releasing hatchery fish in the Hells Canyon Reach, by continued research on natural fish. The information produced by this project will help 1) increase smolt survival; 2) guide supplementation planning; 3) phase in hatchery releases of subyearling fall chinook salmon; and 4) assess the capacity of Snake River rearing areas

to produce fall chinook salmon smolts. Results will continue to be monitored and evaluated annually through real-time analyses, annual progress reports, peer-reveiwed journal articles, and presentations.

Section 7. Project description

a. Technical and/or scientific background.

Fall chinook salmon are currently "threatened" in the Snake River. Supplementing the natural population of Snake River fall chinook salmon with hatchery fish has been proposed as an interim recovery measure and will require thorough monitoring and evaluation. Supplementation was advocated by the Snake River Salmon Recovery Team (Bevan et al. 1994) and the NMFS (1995). The Recovery Team and the NMFS recommended outplanting Lyons Ferry Hatchery subyearling fall chinook salmon to mimic the life history of natural fall chinook salmon in the Snake River above Lower Granite Dam. Conversely, the Washington Department of Fisheries advocated outplanting yearling fall chinook salmon based on higher smolt-to-adult survival from on-station releases (Bugert et al. 1997). A compromise was reached among the federal agencies, state agencies, and the tribes which gave the yearling program first priority at Lyons Ferry Hatchery. An annual production goal of 900,000 yearlings was established, half of which was to be outplanted above Lower Granite Dam.

The Columbia River Fish Management Plan's (CRFMP) section III.D.4 states that the Parties (in agreement with CRFMP) agree to undertake at least the following actions with respect to supplementation:

a. Evaluation of sites suitable for release of hatchery fish at levels of release compatible with natural propagation and harvest management;
b. Rearing and transfer of biologically appropriate fish from existing hatcheries to release sites in the Upper Columbia River Basin to restore natural spawning populations; and
c. Research to determine the effectiveness of these programs

Portable acclimation facilities are being used at Pittsburg Landing in the Hells Canyon Reach of the Snake River, at Big Canyon Creek on the Clearwater River, and will be used at Captain John Creek on the Snake River in 1998. Although yearling fall chinook salmon is the primary age class being used for supplementation, our research using subyearlings is necessary because returning adults will produce progeny with a subyearling life history strategy.

Our study is designed to monitor and evaluate fall chinook salmon survival and supplementation using natural subyearling fall chinook salmon and hatchery yearling and subyearling fall chinook salmon primarily in the Snake River. The use of supplementation is one means of increasing the number of fall chinook salmon, but will not necessarily equate with an increase in survival. It is therefore imperative to identify which variables and mechanisms influence survival to incorporate them into tools that fishery managers can use. One of the major weaknesses of past supplementation projects has been the lack of information compiled on the interactions between hatchery and natural fish (Winton and Hilborn 1994). Since hatchery fish are being used to supplement the natural population, it will be necessary to determine if competition for food and habitat exists, if the health of hatchery fish poses any risk to wild fish, if hatchery and wild fish exhibit differential growth, and if differential predation exists. Presently, hatchery fish are in short supply so determining the optimal size at release, release site, release time, and release pattern will allow for the development of the most appropriate supplementation strategy for fall chinook salmon.

Snake River fall chinook salmon are unique in that they primarily spawn and rear in the mainstem Snake River. This is a significant because the Snake River is a regulated system which can be operated to potentially benefit fall chinook salmon. Both spawning and summer emigration flows are currently provided to increase survival. The need to evaluate survival of both hatchery and wild fall chinook salmon in light of hydropower system operations is critical, as recognized in SRSRP measure 2.1.d.3 “The BPA should evaluate juvenile survival in relation to flow augmentation during downstream migration.” This study is necessary to efficiently manage both fish and the hydropower system.

This study will both directly and indirectly increase the number of fall chinook salmon in the Snake River basin. Dependent upon availability, we will release a total of 40,000 juvenile hatchery fall chinook salmon in the Hells Canyon Reach of the Snake River during each year of the study. This direct increase in the number of juveniles out planted should produce an increase in the number of returning adults. If these adults are allowed to spawn naturally, then an increase in the natural population of fall chinook salmon should be realized. Indirect increases in the number of naturally produced fish will come through knowledge gained from this study which fishery managers can use to optimize survival and therefore increase the number of Snake River fall chinook salmon.

Significant accomplishments produced by this project to date are described in part dX”Project History”

b. Proposal objectives.

The objectives for this study are numbered below.

1) Determine the effects of early life history on natural fall chinook salmon survival to the tail race of Lower Granite Dam.
2) Investigate the occurrence of autumn subyearling and spring yearling emigration in Snake River fall chinook salmon populations.
3) Evaluate post-release attributes and survival of four hatchery rearing treatments of Lyons Ferry fall chinook salmon including acclimated yearlings, non-acclimated yearlings, non-acclimated subyearling parr, and non-acclimated subyearling smolts.
4) Define the effects of post-release attributes and the environmental conditions during rearing and emigration on survival estimates for each hatchery treatment.
5) Use a bioenergetics approach to assess potential growth advantage and predation risk for hatchery treatments and natural fall chinook salmon.

The following **null** hypotheses and assumptions are numbered to correspond to the objectives listed above.
1) Hypothesis: The early life history of natural fall chinook salmon does not influence their survival to Lower Granite Dam.
Assumptions: Snake River fish spawned above the confluence of the Salmon River may survive better because water temperatures are warmer during egg incubation and produce earlier emergence. Early emerging fish will become migrants earlier and be able to take advantage of higher flows and cooler water temperatures and thus have higher survival than later emerging fish that migrate under lower flows and high water temperatures.

2) Hypothesis: Late autumn subyearling emigration and spring emigration of holdover subyearling fall chinook is not related to rearing and migratory conditions.
Assumptions: Fish that do not complete their seaward migration by the end of the summer may originate in the Clearwater or Grand Ronde rivers, which have cooler temperature regimes that may delay growth and migration timing.

3) Hypothesis: Acclimation and size at release does not influence survival of hatchery groups.
Assumption: Larger fish will have higher survival, and acclimation will increase probability of survival. Lyons Ferry Hatchery fall chinook salmon will be suitable surrogates for natural fish.

4) Hypothesis: Temperature and flow do not influence survival of hatchery groups.
Assumption: Higher flows and cooler temperatures contribute to higher survival than lower flows and higher temperatures. The individual effects of flow and temperature on survival can be separated.

5) Hypothesis: Growth and predation risk in nearshore rearing areas do not affect natural and hatchery fall chinook salmon survival.
Assumption: Fish with faster growth will outgrow predators faster and thereby reduce their predation risk and increase their survival.

Products produced by this study will be real-time data and analyses, annual technical reports and peer-reviewed journal publications.

c. Rationale and significance to Regional Programs.

The Northwest Power Planning Council has identified a variety of programs to address the needs of fish and wildlife within the Columbia River basin. This study falls under Program 7.5B.3 “Continue to fund basic life history studies for Snake River fall chinook salmon”, which should, “identify the range, limiting factors, effects of flow, temperature, spawning, and rearing habitat, and migratory behavior.” However, various aspects of this study also fall under other Programs and have produced information useful in management decisions. We have produced current information on juvenile fall chinook emigration timing and rates in the Snake River, which has been used by fishery managers in making flow decisions under Program 5.4B Summer Migrants, which “provides flow for juvenile fall chinook salmon”, and has been relied heavily upon in preparation of recovery planning documents. Our work on spawning, incubation, and rearing requirements for naturally produced Snake River fall chinook salmon has been used to shape flows from Hells Canyon Complex for these life stages under Program 6.1C.2,3 “Provide minimum flows for spawning, incubation, and rearing in Hells Canyon Reach.”

The newest phase of this project focuses on monitoring and evaluation of supplementation as a recovery strategy. The NPPC directed fishery managers to, “develop an experimental design for implementing, monitoring and evaluating supplementation...for Snake River fall chinook,” in measure 7.5B.1. Results of our previous work were relied upon heavily by fishery managers when selecting the locations of acclimation facilities upstream of Lower Granite Dam. Our work focuses specifically on evaluating supplementation by defining the effects acclimation, size at release, and environmental variables have on the survival of hatchery fall chinook. Our research will produce specific, relevant information that can be used in decision making processes and will include the influence of fish age, size, release site, release timing, and acclimation on yearling and subyearling chinook salmon survival through the lower Snake River. Our survival estimates will be useful in evaluating “...flow augmentation during downstream migration” as called for in the SRSRP measure 2.1.d.3.

A major emphasis of our study will be the comparison of performance and interactions between hatchery and wild fish. Any management decisions regarding the use of supplementation to recover wild Snake River fall chinook salmon must consider the positive and negative impacts that hatchery fish may have on the wild stock. This study will not only produce survival estimates, but will examine the underlying mechanisms behind survival so that decisions can be based on an understanding of the processes behind survival. The survival advantage from growth can be framed against risk from predation and can be used to model survival potential under different growth/predation scenarios. Our study task which assesses the extent of smallmouth bass predation on both hatchery and natural fall chinook salmon falls under SRSRP measure 2.8.b.2, which recognizes the need for information on interactions between juvenile salmonids and their predators.

d. Project history

This project has set a standard for cooperation between the NPT, WDFW, NMFS, Idaho Power Company, USFS, COE, USFWS, and USGS. Through cooperative research, it produced much of the empirical data on natrual Snake River fall chinook salmon used for recovery planning. The results of this project have been used in the decision making process to provide summer flows for subyearling chinook salmon in the lower Snake River. In its early phase (i.e., 1991 to 1995), this project produced accurate redd surveys, an estimate of spawning habitat carrying capacity for the Snake River Salmon Recovery Plan, a redd census technique in accord with the recovery plan to measure adult escapement to the spawning grounds, and a model to show the effects of Hells Canyon Complex flows on fall chinook salmon spawning habitat. This information has been used to provide minimum flows during adult spawning and the winter and spring egg incubation and emergence periods in the Hells Canyon Reach. In addition, unprecedented genetic data was collected on natural Snake River fall chinook salmon confirming the uniqueness of this stock. Documentation of the early life history, physiology, and habitat requirements of fall chinook salmon and models to relate juvenile emigration rate to water temperature and flow have been produced as well. Our laboratory data suggest a link between water velocity and migratory behavior. This project has shown that factors such as fish size and water temperature are important to subyearling chinook emigration rate and survival. Our survival work has shown that fish released earlier than later in the season survive at a higher rate and larger fish survive better than smaller fish. Emigration rate from the Hells Canyon Reach to Lower Granite Dam is about 2 km/d (range = 0.6 to 9.3 km/d) and it generally takes subyearling migrants anywhere from 4 to 116 days to reach the dam. This project's radio telemetry work has shown that subyearling chinook salmon tagged at Lower Granite Dam migrate fairly rapidly to the forebay of Little Goose Dam and then can spend considerable time there before passing the dam. This project has helped produce eight technical annual reports. We are currently preparing numerous manuscripts for peer-reviewed publication two of which are being published, and two are in review.

This project has been ongoing since 1991 and has received cumulative funds of 6.6 million dollars to date.

e. Methods.

The scope of this work covers the freshwater life cycle of fall chinook salmon from adult spawning, emergence, nearshore rearing, and seaward migration. It includes work on both natural and hatchery-reared fish. The project focuses research efforts in the Snake and Clearwater rivers because of the need for information to aid recovery of "threatened" fall chinook salmon, and also in the Hanford Reach of the Columbia River because its viable fall chinook population is useful for comparative purposes.

The approach will be to use laboratory experiments and field-collected data to evaluate supplementation strategies and the mechanisms underlying survival such as growth, predation, and migratory behavior.

Detailed methods can be found in our Statement of Work dated August 28, 1997, which was submitted to Debbie Docherty at BPA.

Objective 1. Determine the effects of early life history on natural fall chinook salmon survival to the tail race of Lower Granite Dam.

Task 1. Capture and PIT tag natural fall chinook salmon rearing in different areas of the Hells Canyon Reach.

Methods: The Hells Canyon Reach will be divided into sectionsXan upstream reach above the confluence with the Salmon River, a middle reach from the Salmon River to the Grande Ronde River, and a downstream reach below the Grande Ronde River. Fall chinook salmon will be captured with a beach seine weekly from emergence until no fish can be captured in rearing areas. Fish greater than 60 mm will be PIT tagged. A target of 3,000 fish will be PIT tagged each year if possible. This number of fish is necessary to obtain adequate detections at Snake River dams.

Task 2. Test for differences in detection patterns at Lower Granite Dam of fish tagged in different rearing areas.

Methods: Compile a recapture database of fish detected at Lower Granite and Little Goose dams. Compare the passage distributions of the up and downstream groups using the Kolomogorov-Smirnov test. This information will also be used to forecast annual run timing of wild fish past Snake River dam and will be used by managers to time the release of water for summer flow augmentation.

Task 3. Determine if survival of release groups is related to rearing area, flow, temperature, and travel time.

Methods: Calculate the relative survival of natural fall chinook salmon passing lower Snake River dams based on detection rates. Calculate travel times of release groups. Use ANOVA to test differences in survival and travel time. Use multiple regression to relate travel time to flow, temperature, and rearing area. The expected result is that survival and travel time is positively related to flow, negatively related to temperature, and that fish rearing above the Salmon River confluence may emerge earlier and have higher survival.

Objective 2. Investigate the occurrence of autumn subyearling and spring yearling emigration in Snake River fall chinook salmon populations.

Task 1. Determine the prevalence of subyearling holdover using PIT tag detection data.

Methods: Compile a database of fall chinook salmon PIT tagged as subyearlings and detected in late autumn or in the spring as yearlings. A critical uncertainty is that fish collection at dams ceases in November and does not begin again until the following spring. This means that an unknown number of late migrants may have the opportunity to outmigrate without being detected during this period. This fact may reduce the accuracy of estimates of prevalence of late autumn and winter migration. Notably, ongoing analyses indicate that only a small percentage of emigrating PIT-tagged fall chinook salmon go undetected.

Task 2. Correlate the prevalence of holdover with environmental and genetic data.

Methods: Use correlation analysis to examine the relations between holdover behavior and fish race, tagging location, tagging date, fork length, flow, and temperature. Possible results are 1) late migrants are actually subyearling spring chinook salmon, 2) fish tagged late in the season migrate under poor environmental conditions, which may suppress smoltification and willingness to migrate, and 3) late migrants or holdover fish may originate from the Clearwater River due to delayed growth and outmigration resulting from naturally cooler water in the Clearwater River basin.

Task 3. Determine the feasibility of estimating the origin of holdover fish using genetic and scale pattern data.

Methods: Collect scales and DNA samples from holdover fish. Group fish by rearing area and race. Digitize scale patterns and use discriminant analysis to determine if scale pattern can be used to determine fish origin. Fish from the Grand Ronde and Clearwater rivers, which may experience cooler rearing condition, may be late migrants and their scales may reflect their rearing environment.

Objective 3. Evaluate post-release attributes and survival of four hatchery rearing treatments of Lyons Ferry fall chinook salmon including acclimated yearlings and non-acclimated subyearlings.
<u>Task 1.</u> Obtain and release sufficient numbers of hatchery fall chinook salmon to determine the effects of size at release on survival through lower Snake River dams.
Methods: Release 10,000 acclimated (30 days) hatchery yearlings with 10,000 non-acclimated 95-mm hatchery subyearlings in April at Pittsburg Landing in Hells Canyon. Release 20,000 subyearlings at Pittsburg Landing in June including fork length groups averaging 75 mm, 85 mm, and 95 mm. All fish will be PIT tagged and sample sizes are based on previous work and are large enough calculate precise survival estimates at Lower Granite, Little Goose, and Lower Monumental dams.
<u>Task 2.</u> Estimate survival of each hatchery release group using the SURPH model (Smith et al. 1994).
Methods: Coordinate this activity with National Marine Fisheries Service
<u>Task 3.</u> Use multivariate and analysis of variance statistics to test for similarities between hatchery release groups.
Methods: Use the statistical tests mentioned above to look at the effects to acclimation, size at release, travel time, flow, and temperature on survival of hatchery release groups. Results from 1997 thus far indicate that the survival difference between acclimated hatchery yearling and non-acclimated subyearling fall chinook salmon is related to fork length at release and date of release. Releasing 95-mm long subyearlings in April may result in smolt survival equal to that of yearlings released in April. The benefit of 1998 releases will be the addition of a different water year with a different set of environmental variables to relate to survival.

Objective 4. Define the effects of post-release attributes and the environmental conditions during rearing and emigration on survival estimates for each hatchery treatment.
<u>Task 1.</u> Determine post-release dispersal patterns of hatchery fish in Hells Canyon.
Methods: Recapture hatchery fish in rearing areas of Hells Canyon by beach seining weekly.
<u>Task 2.</u> Describe post-release habitat use by hatchery fish to determine the extent of hatchery-wild overlap in nearshore rearing areas.
Methods: Use point electrofishing to capture both hatchery and natural fall chinook salmon in a variety of rearing habitats. Use principal components analysis, discriminant analysis, and multiple regression to describe habitat use and overlap by both groups. Use remote sensing to collect additional habitat information in the Hells Canyon Reach and the Hanford Reach. Input habitat data into a GIS. An expected result is that rearing habitat is a potentially limiting factor to fall chinook salmon. Compared to the Hanford Reach, which produces millions of parr, Hells Canyon is morphologically different and may not be able to support a great number of fall chinook. If true, we will need to know the how many juvenile chinook the Hells Canyon Reach can support in the face of releasing fish for supplementation.
<u>Task 3.</u> Use radio telemetry to describe the migratory behavior of active migrants in the

lower Snake River.
Methods: Tag 210 natural fall chinook migrants at Lower Granite Dam and use mobile and fixed-site radio telemetry to determine fish travel times to Little Goose Dam, forebay residence times, dam approach patterns, and use of available water temperatures and velocities. Six releases of 30 fish each made weekly is sufficient for obtaining repeat locations and detections at Little Goose Dam to estimate travel rates. The expected results are similar to those already obtained by this project, are travel rate through the reservoir is fairly rapid, but delays greater than 7 days can occur in the forebay for about 20% of the population.
<u>Task 4.</u> Use multivariate and analysis of variance techniques to determine if differences in survival are related to temperature, flow, and travel times.
Expected results are similar to those of Objective 3, Task 3.

Objective 5. Use a bioenergetics approach to assess potential growth advantage and predation risk for hatchery treatments and natural fall chinook salmon.
<u>Task 1.</u> Develop a bioenergetics model to predict food consumption and growth of hatchery and wild fish in nearshore rearing areas.
Methods: Collect food habit information from both hatchery and natural fall chinook salmon in rearing areas. Develop a bioenergetics model for juvenile fall chinook that will predict consumption and growth of hatchery and natural chinook under various supplementation scenarios. The expected result is that fish in rearing areas are feeding at maximum consumption rates, however, it is unknown whether adequate food resources exist for migrants in reservoirs, or whether high water temperatures are driving up metabolic costs to the point that fish health and survival may be compromised. The bioenergetic approach will allow us to explore these possibilities.
<u>Task 2.</u> Determine the extent and size selectivity of predation by smallmouth bass on hatchery and wild subyearling fall chinook in the Hells Canyon Reach.
Methods: Collect smallmouth bass in Hells Canyon by electrofishing, lavage their stomachs, and tag for mark-recapture. Identify stomach contents to estimate the extent of predation on juvenile fall chinook salmon. Use mark-recapture techniques to determine the relative abundance of smallmouth bass in sampling reaches. The expected result is that predation may be high after hatchery releases and near release sites. Whether a feeding response in smallmouth bass causes increased predation pressure in wild fish is uncertain.
<u>Task 3.</u> Use an individual-based bioenergetics model to synthesize predation risk and growth advantage as it relates to survival, supplementation scenarios, and environmental conditions.
Methods: Some of the input variables will be prey size, growth rates, prey density, predator density, water temperature, and predator-prey encounter probability. Outputs will likely be chinook losses to predation under different levels of initial densities, temperatures, and growth.

f. Facilities and equipment.

The Columbia River Research Laboratory is equipped with all of the resources necessary to carry out this project. Each person employed by this project has a computer and the necessary software to complete data reduction, storage, and complex statistical analyses. In addition, we have a state of the art GIS computer system and software at the lab. Our wet lab has been used for years to conduct experiments to meet project objectives. It is supplied with well water, and has an aeration system to provide air to each holding tank, complete photoperiod and temperature control, and we have a full-time wet lab supervisor who oversees and maintains the facility. As for field activities, this project has all the boats, vehicles, and capital equipment necessary collect data for field related tasks. Our radio telemetry activities use state of the art miniature radio tags and digital receivers.

Our project cooperators (USFWS) are also equipped with the necessary office space, equipment, boats, vehicles, and personnel to accomplish project objectives.

g. References.

References:

Bevan, D. and several co-authors. 1994. Snake River Salmon Recovery Team: Final Recommendations to the National Marine Fisheries Service.

Bugert, R.M., G.W. Mendel, and P.R. Seidel. 1997. Adult returns of subyearling and yearling fall chinook salmon released from a Snake River hatchery or transported downstream. North American Journal of Fisheries Management 14: 638-651.

Burnham, K.P., D.R. Anderson, G.C. White, C. Brownie, and K.H. Pollack. 1987. Design and analysis methods for fish survival experiments based on release recapture. American Fisheries Society Monograph 5, ISSN 0362-1715, Bethesda, Maryland.

Jager, H.I., and seven coauthors. 1993. An individual-based model for smallmouth bass reproduction and young-of-year dynamics in streams. Rivers 4:91-113.

National Marine Fisheries Service. 1995. Proposed recovery plan for Snake River Salmon. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration. Portland, Oregon.

Winton, J., and R Hilborn. 1994. Lessons from supplementation of chinook salmon in British Columbia. North American Journal of Fisheries Management 14:1-13.

Section 8. Relationships to other projects

This study is a collaborative effort between the Biological Resources Division (USGS), U.S. Fish and Wildlife Service (study cooperators), National Marine Fisheries Service (Project 9402900), Nez Perce Tribe of Idaho (Project 9403400), and Washington

Department of Fish and Wildlife. Collaboration is necessary to maximize the use of research fish, which are often in short supply, so each project can accomplish its study objectives, avoid duplication of effort, and minimize project costs. Specific areas of collaboration include joint efforts to PIT tag and transport hatchery fish to release sites, collecting and sharing data such as recapture information, and the calculation of survival estimates. It is necessary for all three projects to make a single request for research fish each year from the Production Advisory Committee. The Washington Department of Fish and Wildlife's cooperation is critical to the study as they produce and grow research fish to the appropriate size, and allow the use of their facilities at Lyons Ferry Hatchery for PIT tagging.

Since a portion of this study involves natural Snake River fall chinook salmon, which are listed as threatened under the Endangered Species Act, we have obtained the necessary state and federal permits to proceed with the project.

Section 9. Key personnel

Project Manager:
Dennis W. Rondorf
Research Fisheries Biologist, 1 FTE

EDUCATION:
M.S. Oceanography and Limnology, University of Wisconsin, Madison, 1981
B.S. Wildlife Management, University of Minnesota, St. Paul, 1972

CURRENT EMPLOYMENT AND RESPONSIBILITIES:
D.W. Rondorf serves as a Fishery Research Biologist and Section Leader for the Anadromous Fish Ecology section at the Columbia River Research Laboratory, Biological Resources Division, U.S. Geological Survey, Cook, Washington. Current areas of research include the behavior and ecology of Snake River wild and hathery fall chinook salmon, the distribution of smolts and relation to gas supersaturation in the main stem Columbia River, and behavior of smolts to evaluate a prototype surface collector at Lower Granite Dam, Washington. In recent years, D.W. Rondorf has lead research teams using radio telemetry, geographic information systems (GIS), global positioning systems (GPS), remotely operated underwater vehicles (ROV), hydroacoustic fish stock assessment systems, and acoustic Doppler current profilers (ADCP) as research tools. Between 1979 and 1997, D.W. Rondorf was employed by the research division of the U.S. Fish and Wildlife Service and the National Biological Service to conduct research on juvenile salmon in the Columbia River basin.

Adams, N.S., D.W. Rondorf, S.D. Evans, J.E. Kelley, and R.W. Perry. 1998. Effects of surgically and gastrically implanted radio transmitters on swimming performance and predator avoidance of juvenile chinook salmon. (*In Press*) Canadian Journal of Fisheries and Aquatic Sciences.

Adams, N.S., D.W. Rondorf, S.D. Evans, and J. E. Kelley. 1998. Effects of surgically and gastrically implanted radio transmitters on growth and feeding behavior of juvenile chinook salmon. Transactions of the American Fisheries Society 127:128-136.

Parsley, M.J., D.W. Rondorf, and M.E. Hanks. 1998. Remote sensing of fish and their habitats. Proceedings of instream and environmental flows symposium-technology and policy issues. (*In Press*) North American Lake Management Society and others, Denver, Colorado.

Adams, N.S., D.W. Rondorf, E.E. Kofoot, M.J. Banach, and M.A. Tuell. 1997. Migrational characteristics of juvenile chinook salmon and steelhead in the forebay of Lower Granite Dam relative to the 1996 surface bypass collector tests. U. S. Army Corps of Engineers, Walla Walla, Washington.

Principal Investigator:
William P. Connor
Fisheries Biologist, 1 FTE

<u>Education</u>:
Master of ScienceX1988; Montana State University; degree in Fish and Wildlife Management
Bachelor of ScienceX1984; West Virginia University; degree in Fish and Wildlife Management

<u>Employment</u>:
1991 to PresentXFishery Biologist for the U.S. Fish and Wildlife Service. Conducting research on fall chinook salmon in the Snake and Clearwater rivers.

1987 to 1991XFishery Research Biologist for the Nez Perce Tribe of Idaho. Conducted fall chinook salmon research in the Clearwater River.

<u>Current Responsibilities</u>:
Principle investigator for the U.S. Fish and Wildlife Service who are cooperators on this project. Responsible for oversight of Snake River fall chinook salmon redd surveys, juvenile seining and PIT tagging efforts, supplementation/survival releases and analysis, and emergence and outmigration forecasting.

<u>Expertise</u>:
William Connor has over 10 years as a fishery biologist focusing on Snake River fall chinook salmon research. He has been involved with all Snake River fall chinook salmon research conducted upstream of Lower Granite Dam since 1987. His research efforts provided fishery managers with new empirical information on Snake River fall chinook salmon redd surveys, spawning habitat availability, spawning habitat quality, early life history, travel time analyses, juvenile run timing predictions, survival, supplementation, and summer flow augmentation.

<u>Work Products</u>:
XSeveral journal manuscripts are in preparation including one accepted for publication in the North American Journal of Fisheries Management.

> Connor, W. P., H. L. Burge, and D. H. Bennett. In Preparation. Detection of PIT-tagged subyearling chinook salmon at a Snake River dam: Implications for summer flow augmentation. North American Journal of Fisheries Management. Expected to be published in the spring issue 1998.

XCoauthored nine BPA annual reports
XPresented eight different papers at formal meetings with attendance > 100 persons

Principal Investigator:
Kenneth F. Tiffan
Research Fisheries Biologist, 1 FTE

Education:
Master of ScienceX1992; Colorado State University; degree in Fishery Biology
Bachelor of ScienceX1987; Colorado State University; degree in Fishery Biology
Employment:
1992 to PresentXResearch Fisheries Biologist for the Biological Resources Division (USGS). Conducting research on fall chinook salmon in the Snake and Columbia rivers.

Current Responsibilities:
Assistant project manager. Responsible for oversight of research conducted by BRD employees including radio telemetry, bioenergetics, habitat/GIS studies, and predation, and coordination of BRD and USFWS research. Responsible for editing annual project reports, budgeting, and obtaining necessary fish collection.

Expertise:
Kenneth Tiffan has over 5 years as a fishery biologist focusing on Snake and Columbia river fall chinook salmon research. He has been involved with this project since 1992 and has experience in fall chinook salmon physiology, field and laboratory investigations of migratory behavior, and habitat use. He has been instrumental in information transfer for this project by coordinating, authoring chapters, and editing annual project reports. His knowledge of political and administrative processes help keep these impediments from hindering project operations and accomplishments.

Work Products:
XCoauthored and edited four annual project reports.
XTwo journal manuscripts are in preparation; one entitled "Physiological development and migratory behavior of subyearling fall chinook salmon in the Columbia River" for submission to the North American Journal of Fisheries Management, and the other, untitled as yet, dealing with age, race, and morphology of subyearling chinook salmon in the Snake River for submission to Transactions of the American Fisheries Society.
XTwo informal presentations on fall chinook physiology have been given, one to the 18th annual Smolt Workshop in Corvallis, Oregon in 1995, and the other to the Fall Chinook Coordination Meeting in Lewiston, Idaho also in 1995.
XA formal paper entitled "Osmoregulatory and ATPase development in subyearling fall chinook salmon in the Columbia River" was presented at the International Congress on the Biology of Fishes in San Francisco, California in 1996.

Section 10. Information/technology transfer

Information obtained will be disseminated in annual technical project reports, peer review publications, presentations to work groups such as FPAC and the PATH work group for fall chinook salmon, and at professional meetings. Geospatial data generated under habitat-related tasks will be made available electronically as meta-data via the National Geospatial Data Clearinghouse internet website. Our estimates of natural fall chinook salmon emergence dates and run size and timing will be made available to the Fish Passage Center annually for their oversight of smolt monitoring activities at Snake and Columbia river dams and to fishery managers for summer flow augmentation.